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Curiosities Among the New Guinea Canes

By J. H. BUZACOTT

Amongst the 30,000 different seedling varieties of sugar cane which are raised in Queensland each year it is not at all unusual to find stalks which show abnormalities of growth. In the subsequent selection of varieties for commercial purposes from the original seedlings, those which show abnormalities are generally discarded and the occurrence of "freaks" in approved varieties is comparatively rare. Among the many new varieties which were introduced to Queensland by the 1951 New Guinea Expedition quite a number of interesting curiosities have appeared and it is thought that a description of some of these might be of interest to cane farmers.

Abnormalities of Stalk Shape.

The stalk shape of sugar cane varies considerably with the variety but generally falls into one of several main types. These are the barrel-shape in which the diameter of the internode is greater than that of the node; the spindle, or bobbin-shape, in which the internodal diameter is less than that of the node; conoidal, in which the diameter of the internode tapers from an enlargement just above the node to a constriction below the next node above it; obconoidal, which is opposite in shape to conoidal, that is to say the larger diameter is at the top of the internode and the smaller diameter towards the base of the internode; and cylindrical, in which the diameter of node and internode is the same. An extraordinary example of the barrel-shaped internode occurs in 51 N.G. 131, a variety collected near Nadzab. When this cane is well grown the internodes are almost egg-shaped; it is illustrated in Fig. 1, but at the time this photograph was taken only relatively small stalks were available and the internodes become very much more swollen still when the variety is grown under favourable conditions. In addition to its curious stalk shape, 51 N.G. 131 is quite striking by virtue of its distinctly zigzag appearance and the handsome stalk colour, which is bright red with green stripes. It is interesting to note that Leonard Wray, the author of "The Practical Sugar Planter," in 1848 referred to a similar egg-shaped cane which was collected in New Hebrides and grown to some extent in Mauritius prior to 1848.

Cane varieties are not uncommonly obconoidal in shape at the lower internodes, but it is not common to meet with this shape to any marked degree in the upper portions of the stalk. Figure 2 shows the upper internodes of the variety 51 N.G. 95, which was found both in the Chimbu and Mt. Hagen districts. The distinct inverted cone shape of the internodes of this variety results in corresponding cone shape of the root band.

The condition in which a very short internode is interposed between internodes of normal length is commonly known as "knee-joint." It is often found in seedling canes and is sometimes observed in commercial varieties such as M.1900 Seedling; for instance, the West Indian variety B.4098 is characterised by an occasional joint of this description. The variety 51 N.G. 121, collected at Lae, and shown in Fig. 3, is one which is characterised by an unusual number of "knee-joints" and in the illustration three are visible, a single one at the top of the picture and a double one at the bottom with an internode of normal length between.

Fig. 1—51N.G.131, a green and pink striped cane with bulging internodes.

Fig. 2—The inverted cone-shaped internodes and conical root band of 51N.G.95.

Stem galls and the adventitious buds associated with them were briefly referred to by the writer in the "Cane

Growers' Quarterly Bulletin for July, 1953." A variety found at Mendi, almost in the geographical centre of New Guinea, when collected did not appear to be affected with stem gall. Since being grown at Meringa it has shown stem galls on almost every internode. Whilst some of the galls have developed adventitious buds most of them remain as large calluses on the internode and generally they appear on the side of the internode opposite to the bud, accordingly affecting adjacent internodes on opposite sides. This variety is 51 N.G. 103 and Fig. 4 shows the type of gall it develops. The somewhat similar condition known as "bunch-top," in which numerous shoots appear at the top of the cane, was found in a seedling produced from seed of the *robustum* variety 51N.G.91A as shown in Fig. 5.

Fig. 3—Knee-joints on 51N.G.121.

Fig. 4—Stem galls on 51N.G.103.

Colour Effects.

Commercial sugar canes have stalks of almost every shade of colour ranging from palest green to deep purple. Sometimes "sports" occur in the form of striped stalks. On rare occasions a striped sport has been propagated by a cane farmer and one or two have been grown on a commercial scale in Queensland, one notable one being a striped sport of Clark's Seedling. With an eye for gaudy colours the New Guinea natives almost invariably propagate striped sports when they are found, with the result that striped varieties are very common in all native gardens, whilst in a few gardens they are the rule rather

Fig. 5—Seedling from the *robustum* 51N.G.91A showing "bunch-top."

than the exception. The colour combinations have a wide diversity and the stripes on some form a striking contrast. The picture in Fig. 6 depicts three varieties with different colour combinations. Commencing from the left 51N.G.130 is green with pink stripes, a colour combination which it shares with the cane with the egg-shaped joints referred to earlier; 51N.G.115, shown in the centre, is green with purple stripes, whilst the variety on the right, 51N.G. 101, is orange with purple stripes.

Another variety which has a striped appearance, but due to a different cause, is 51N.G.154. This is a reddish-purple cane which is covered with cork patches arranged in the form of longitudinal stripes. This variety is shown in Fig. 7 and when it is young it presents a marbled effect of cream on a dark red background.

Still another curiously marked stalk is that of 51N.G.88. At Niglguma natives were noticed carrying thin canes of a light greenish colour but marked with a regular brown pattern. It was at first thought that this pattern had been burnt on to the stalks in the same manner as the native decorate their pipes, flutes and walking sticks; however, on being conducted to a grove where the cane plants were growing, it was realised that the markings were natural. This cane is believed to be a species of *Miscanthus*, a plant which strongly resembles wild *Saccharum*. Figure 8 is a photograph of sticks of it taken from stools now growing at Meringa.

Hairiness.

Most of the New Guinea noble canes have relatively little of the spiny hair

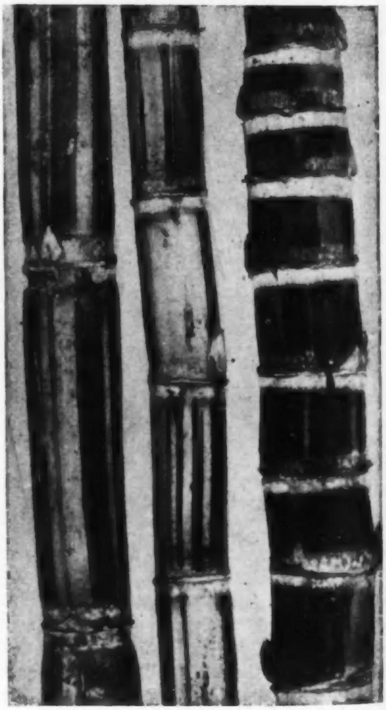

Fig. 6—Striped canes: left, 51N.G.130, green with pink stripes; centre, 51N.G.115, green with purple stripes; right, 51N.G.101, orange with purple stripes.

Fig. 7—51N.G.154, a reddish-purple variety with longitudinal coloured cork patches.

growth on the leaf sheath which in Queensland is usually referred to as "hairy-mary." This is possibly due to the fact that the natives refrain from planting as chewing canes those which develop this hairy growth, as one can imagine the irritation the spines would cause them with their lack of protective clothing. Some of the wild *robustum* varieties are, however, well armed with most aggressive hairs. Such a one is 51N.G.27, which was found growing as a garden fence at Goroka. The picture in Fig. 9 shows the very strong developments of hairs on the leaf sheath and also the long hairs on the edges of the leaves. In this variety hairs also grow on both upper and lower surfaces of the leaves. Possibly the aggressive hairs of 51N.G.27 render it particularly suitable for use as fencing material. Another notable feature of this particular variety is the extraordinarily long upward extension of the leaf sheath known as the "auricle" and which is very noticeable in the photograph.

It is very rare to find hairs growing on the stalks of cane varieties. When this does occur the hairs are usually confined to the bud groove. Artschwager, a well-known American sugar cane botanist, has noted that among all the sugar cane varieties he has examined he has only found one or two with downy hairs covering the stalk. It is interesting to find therefore that 51N.G.89, collected in the Chimbu district, possesses hairy stalks. The fine hairs show up quite well in the photograph reproduced in Fig. 10 and, as can be seen, there is a greater concentration of hairs towards the lower portion of the internode.

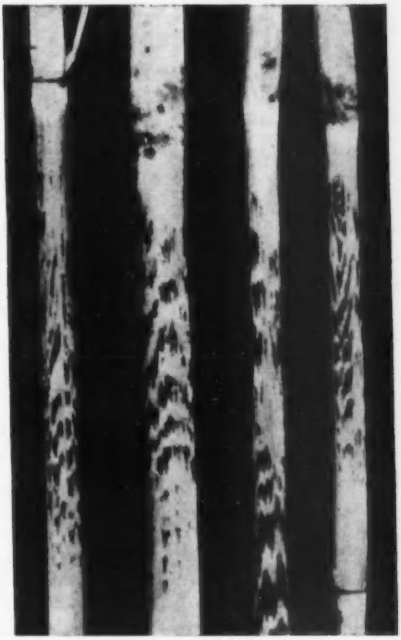

Fig. 8—Curious pattern on stalks of 51N.G.88, a species of *Miscanthus*.

Fig. 9—Heavy hair growth on 51N.G.27. Note also the long auricles.

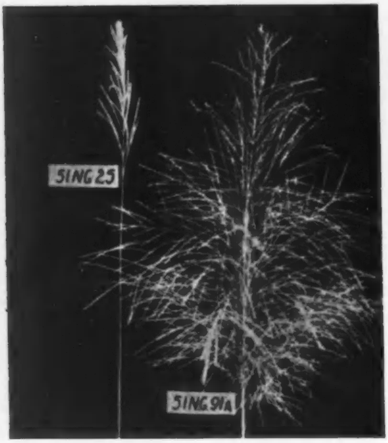

Fig. 11—The large arrow of 51N.G.91A (right) contrasted with the small one of 51N.G.25 (left).

Size of Arrow.

The canes which were observed arrowing in New Guinea were mainly wild varieties and the size of arrows produced varied enormously. An interesting comparison between some of the very large arrows of a giant

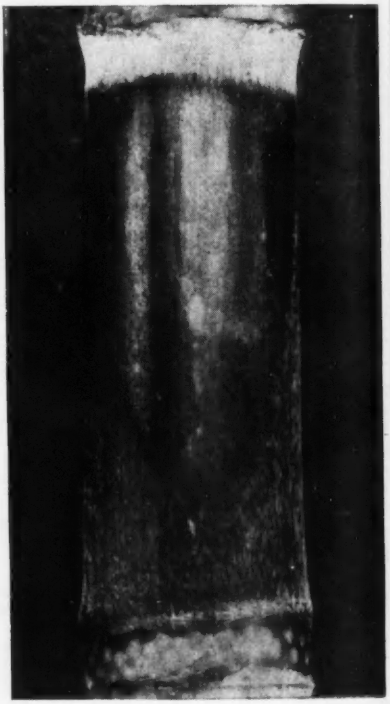

Fig. 10—51N.G.89, a cane with hairy stalks

robustum cane 51N.G.91 and the very small arrows of a miniature *spontaneum* variety 51N.G.25 is well illustrated by Fig. 11. The arrows of noble canes are usually intermediate in size between those of the wild species mentioned.

Rich Land and Low Sugar*

By J. H. BUZACOTT

Introduction.

One of the many problems of the sugar cane breeder is that of tailoring varieties to fit certain areas to which the normal approved varieties of a district are unsuited. For instance, the exceptionally poor soils of a district may merit the development of a very vigorous variety which would lodge on soils of even medium fertility; or a badly drained soil type may require a variety which can survive and grow even when its roots are waterlogged for long periods. A major problem of some of the far northern mill areas is that of rich pockets of alluvial soil on which most varieties lodge and where the sugar content is unusually low. This problem, which has become increasingly worse in recent years, occurs mainly in sections of the rich river and creek flats of the far north in regions of high rainfall and humidity. That the problem is very real is indicated by the fact that in 1953 one grower sent to a northern mill over a thousand tons of cane, most of which had a c.c.s. of under seven per cent. Needless to say, the harvesting of large quantities of cane of this inferior sugar content is unprofitable to both grower and miller. In the particular instance cited it was realised that under the conditions operating the sugar content of the crop would not improve and would probably deteriorate even further if left for later harvest.

Most northern mills are faced with the crushing of tonnages near the limits of their present capacities within an economic crushing period. It is not surprising to find, therefore, that some of these mills are threatening to refuse to crush crops of cane of which the sugar content is below seven per cent. In doing this they are quite within their rights since the schedule of payments sanctioned by the Sugar Cane Prices Board provides that cane which analyses less than seven per cent c.c.s. may be refused acceptance by the mill and, further, that it is not obligatory upon the mill to pay for such cane which it may have to crush in order to determine the c.c.s. Most mills, particularly co-operative ones, have hesitated to invoke these regulations to the degree of refusing either acceptance of, or payment for, the cane. Now, however, some mills at least will be forced to refuse low value crops in favour of those which give a greater return of sugar.

Areas Involved.

The areas mainly concerned comprise rich pockets on river and creek flats in the high rainfall area north of Townsville. Certainly rich soil types occur in the Burdekin district, but owing to a lower rainfall and the depletion of surface moisture in that district during the dry months of the year, the withholding of irrigation water can cause sufficient check to allow the sugar content of the cane to increase. The rich alluvial pockets of the Mackay and Proserpine districts also suffer to a lesser degree since there is a longer period of cold weather there and this allows a greater time for the development of a reasonable sugar content before rapid growth of cane recommences in the spring months. The lands with which this paper deals are subject to flooding which is often severe, the cane at times remaining completely submerged for several days. The rich silty loams occur due to the fact that the pockets are generally situated in backwaters of a river's flow and although cane is seldom uprooted by the rush of flood water, the deposition of silt does cause serious damage to the crop. If the crops lodge, the sticks root strongly and it is not uncommon for the lodged portions of the stalks to become completely buried in the silt.

*Reprinted from the Proceedings of the Q.S.S.C.T., 1954.

Causes of Low Sugar.

Investigations have been conducted into the causes of rank growth and low sugar on these lands and information obtained from the growers concerned and from independent observations leads to the conclusion that several factors have a bearing on the problem—

Fertilizer usage.

Time of planting.

Varieties.

Factors beyond the control of the grower.

The first three of these items are under the control of the farmer and attention to recommendations in these respects will eliminate the trouble experienced at least in some instances. For the fourth item, which comprises all the factors beyond the control of the farmer, it is most difficult to recommend a cure. Each of the four categories will be dealt with in turn.

Fertilizer Usage.—The lands referred to are generally rich and flooded; in consequence their fertility is maintained, and addition of artificial fertilizer is unnecessary. Unless analysis shows a marked deficiency in any of the major plant foods it is unwise to apply fertilizer. The soils are well supplied with organic matter which has been washed down from the rain forests and deposited by floods. Although temporary nitrogen starvation may occur, one of the principal problems is the presence of an excess of nitrogen. If bad yellowing of the crop indicates a temporary lack of available nitrogen a small amount of sulphate of ammonia might be desirable to carry over the period of temporary nitrogen shortage. Van Dillewijn [1] cites various authors who have given evidence to show that the cane quality steadily decreases with increasing rates of application of nitrogen. Since nitrogen is undoubtedly present in excess of the requirements of cane for normal growth on the soil types under discussion, the greatest care should be exercised when considering the application of further nitrogen even to overcome the temporary non-availability of that element brought about by the rotting down of organic matter.

Time of Planting.—Other things being equal, cane with greater age tends to have a higher sugar content early in the season and growers often reason that early planting, that is during April or May, is most likely to give them a reasonable c.c.s. at harvest time. This usually, however, defeats its own purpose because on the rich land early planted cane often lodges even before the monsoonal rains commence. The flooding of the lodged crop results in a deposition of silt and subsequent rotting of the cane so that it is not worth harvesting. It is, therefore, desirable that planting should be delayed until July or August. On the other hand, it is not wise to plant later than this because it is desirable to harvest the cane early and cane which is planted too late would be too young to achieve a satisfactory sugar content during the short winter period; furthermore, small cane suffers to a greater degree from flooding than does taller cane. It is wise to harvest early because the slight check brought about during the cool winter weather does usually result in some increase in sugar content and the difference between a c.c.s. of, *say*, seven or eight per cent. in June and a mill average c.c.s. of, *say*, 12 per cent. is not as great as it would be in September or October when the mill average might be 15 per cent. whilst that of the block being harvested might still be only nine per cent. The most satisfactory timing would therefore appear to be planting in July or August and harvesting in June or July if the c.c.s. has reached a value higher than seven per cent. If at that period the c.c.s. is below seven per cent. there is little choice but to wait until it improves. It should be remembered, however, that in the presence of adequate moisture and excess of nitrogen the cane will again move into rapid growth as soon as the weather warms up. This will result in at least no improvement in sugar content, with a possibility of further lodging.

Use of Varieties.—There is no possibility of checking growth on these fields by controlling the moisture or the temperature of the soil. To some extent it can be checked, through control of the nitrogen content by refraining from the application of fertilizer. Where fertilizer is not applied and the rank growth and low sugar are still experienced the problem may be varietal. The question of suitable varieties is a difficult one. With the high cutting rates which damaged cane now attracts the use of a flood susceptible variety is almost out of the question. Formerly it was the custom to grow Badila on these areas but it has two major disadvantages—susceptibility to flood damage and lodging. When Badila is flooded the growing points of the stalks are killed and the buds then shoot. At harvest time each original stalk has as many as six or more aerial stalks growing out from it, each of different length and each requiring to be topped separately. It does, however, possess some advantages. It is not unduly long and when it lodges it does not become a tangled mass; it has heavy foliage and burns well under almost any conditions; its sugar content even when lodged usually reaches a figure which is acceptable to the mill. Of late years Badila has waned in popularity, partly because of these disadvantages and partly because its yields are generally not comparable with those of recent hybrid varieties. Its place on the lowlands has been taken to a large degree by Trojan. The introduction of this variety to flooded lands was a real boon because of its high degree of flood resistance even at a comparatively early stage of growth. It has proved a very valuable variety in most flooded fields except those rich pockets which are the subject of this paper. In these soil types it may lodge badly whilst its relatively late maturity prevents it from attaining a satisfactory sugar content before the rapid spring growth referred to above commences. It is also a poor burning variety and this causes much difficulty on rich wet soils where weed growth is strong and rapid. Nevertheless, of the varieties at present on the approved lists, Trojan is probably still the best to grow on these soil types. Pindar is better from an early maturing point of view but on account of its vigorous growth it lodges so easily that it is a hopeless harvesting proposition. Recently the variety Ragnar, produced by the C.S.R. Co., has been added to the approved lists of the Ingham district in an endeavour to fulfil the demand in that area for a variety to suit areas of rank growth. In trials in the Mulgrave area, this variety lodged as badly as Pindar and it cannot be regarded as the ultimate solution of the problem. In fact it is obvious that there is no variety at present on the approved lists really suited to the rich lands in question and from which a crop with even a reasonable sugar content could be assured.

Factors beyond the Growers' Control.—The factors which are beyond the power of the farmer to control include such items as the richness of the soil, its moisture content, the temperature and the degree of flooding. All these vary somewhat from year to year, particularly the last one and the only one of them which is amenable to any sort of control is the richness of the soil. It is possible once a crop is established to continue to grow ratoons until the soil is impoverished to some extent. This is indeed practised by some farmers who, not without reason, consider that a crop of 35 tons per acre of fifth or sixth ratoons at or near mill average c.c.s. is a better paying proposition than a 50-ton crop of plant or first ratoon which is four or five units below mill average. On the other hand, this practice leads to rotation difficulties whilst the problem of passing through the plant and early ratoon crops still has to be faced.

For those fields which produce rank low-sugar crops in spite of late planting, early harvest and no fertilizer applications, the only practical solution of the problem appears to be the breeding of cane varieties especially for the particular conditions. This project forms an integral part of the cane breeding

programme of the Bureau of Sugar Experiment Stations at the present time. For the past several years crosses have been made with a view to establishing those which produce the type of progeny required. Also the selection processes have been aimed at including among the general selections varieties which might prove suitable to the rich soils. It would seem that a variety of only medium vigour is required but it must be a hardy ratooner and flood resistant. It must also definitely possess a good sugar content early in the season so that advantage may be taken to harvest during the winter check in growth. A further requirement is that it should have relatively good cover because on the river flats weed growth is tremendous and the presence of grass and weeds greatly interferes with the burning capacity of the cane and adds to harvesting costs.

Although it takes from eight to ten years to produce a commercial variety this project has been under consideration long enough to have a number of varieties undergoing trial, and each year it is proposed to plant a further series of these varieties out on farms where the appropriate conditions occur. One problem that has been encountered is the fact that identical conditions are not experienced every year. In some years flooding is worse than in others, whilst in a slightly drier season not even the standard varieties lodge. Such seasonal vagaries make the testing of varieties for this type of land particularly difficult.

Some of the varieties under test are already showing promise. The most advanced of these is Q.57, which should be available on the approved lists of a number of northern mills in 1955. This variety has performed well in districts from Mossman to the Budekin, although for no accountable reason it has shown very little promise at Innisfail. Q.57 is a strong stooler with a light top but good cover. It remains erect in heavy crops and is an earlier maturer than Trojan. In these respects it suits the requirements admirably. Unfortunately it has two bad habits on rich soil. It suckers rather freely and it lodges badly if burnt with a "hot" fire. The suckering may not matter if the crop is harvested early but it occurs very freely in spring growth and may, as in 1953, result in greatly depleted sugar content if harvesting is delayed until the appearance of suckers. Lodging when burnt is due to the variety being a self-trasher. The trash collects at the bottom of the stools and the resultant "hot" fire concentrated at the base of the long stalks results in the sticks lodging badly. This can be controlled to some dgree by burning in the early morning or when the cane is damp. Apart from these disabilities the possible value of Q.57 is well indicated by the results of a randomised trial planted during 1951 on a rich river silt block in the Mulgrave area. The trial included Trojan, Pindar, Ragnar and Q.57. Pindar and Ragnar lodged very badly in both plant and ratoon crops and so badly in ratoons that it was virtually impossible to harvest the trial. Some of the Trojan plots lodged whilst only portion of one replicate of the Q.57 reached a semi-lodged state. The plant crop was sampled in June at 11 months of age and the c.c.s. of Q.57 was 10.7, whilst that of Trojan was 6.2. In the first ratoons, sampled the following June at 11 months of age, Q.57 gave a c.c.s. of 12, whilst that of Trojan was 7.9. In the plant crop which was harvested at 12 months of age, Q.57 cut 55 tons per acre and Trojan 54 tons per acre. It will readily be appreciated that under the conditions of this trial the Q.57 showed up in a favourable light when compared with Trojan. This advantage is however largely lost if the variety is not harvested until later in the season. Propagation plots on similar land, when left until October to harvest, produced a mass of giant suckers which considerably reduced the c.c.s.

Other varieties are also undergoing trials on rich flooded fields although the necessity for heat treatment to eliminate ratoon stunting disease has caused a slight delay in their propagation. It is confidently believed that in the near

future suitable varieties will be available to enable the comparatively few growers with over-rich soil types at least to be sure of a harvestable crop and at the same time to free millers from the responsibility of refusing to accept portion of a grower's crop for crushing.

Summary.

The causes of low sugar content of canes grown on certin flooded alluvial soil types are discussed. In some instances an improvement can be brought about by the grower by careful attention to time of planting, fertilization, time of harvest and varieties planted. In certain cases, however, it is considered that the only possibility of improvement lies in the breeding of varieties to suit the type of land. Reference is made to efforts being made along these lines by the Bureau of Sugar Experiment Stations.

REFERENCE

[1] **Van Dillewijn, C.:** 1952. "Botany of Sugar Cane," p. 215.

Conference of Cane Pest and Disease Control Boards

The sixteenth annual conference of Cane Pest and Disease Control Boards was held in the Parish Hall, Mackay, on 29th April, 1954, when there was a record attendance of 50 delegates who represented the various cane-growing. districts from Mossman to Nambour Eleven officers of the Bureau of Sugar Experiment Stations also attended in an advisory capacity.

Mr. N. J. King, Director of Sugar Experiment Stations, in welcoming delegates on behalf of the Hon. H. H. Collins, Chairman of the Sugar Experiment Stations Board, mentioned that some might query the reason for this conference in view of the fact that many diseases had been eradicated, but with changing circumstances other equally important diseases had come into the picture, and it was essential that efforts towards their control should not be relaxed. In response to his invitation to appoint a chairman, Mr. D. A. McIntosh (Mackay) was unanimously elected, and he subsequently presided over the day's proceedings. He introduced the Mayor of Mackay, Alderman J. A. Binnington, and asked him to officially open the conference. In doing so, Alderman Binnington referred to the devastation caused by pests and diseases, and said it was pleasing to see the ways in which science was coming to the aid of the primary producer. He wished them well in their discussions and hoped that their stay in Mackay would prove pleasant.

The first paper, which was presented by Mr. G. Wilson on "Cane Grub Control by BHC," showed that when substantial grub infestation was encountered on light red soils the single heavy application of BHC to the plant crop gave a significant increase in cane yield over the lighter applications which were made in expectation of an additional amount being applied to the ratoon crop. Furthermore, no differences in the ratoon crop were demonstrated where this retreatment was carried out. He recommended the single BHC application as a means of lowering costs.

In a paper dealing with bird damage to cane crops in the South Johnstone area, Mr. A. R. Taylor drew attention to the trouble that was being experienced on certain farms as a result of shining starlings roosting on the cane leaves at night, thereby breaking the leaves and the growing point of the stalk. As this damage was apparently

confined to a small number of farms it was decided to approach the Minister for Agriculture and Stock seeking a permit to destroy these birds where they are causing damage.

Mr. S. Greenaway, in a paper entitled "Some notes on the wallaby pest," detailed the damage caused by the sandy wallaby to cane crops in the Mackay district. Despite an outlay of over £5,000 paid out in bonus payments for more than 42,000 wallabies destroyed during the past eight years there was no noticeable reduction in their numbers. The use of beagle hounds, or beagles crossed with other breeds, was favoured in many localities, where they had been responsible for keeping the pest under effective control. In addition, however, it was decided to approach various Commonwealth and State Departments in an endeavour to interest them in this problem.

Messrs. S. Greenaway, C. G. Hughes and R. W. Mungomery each contributed papers dealing with some aspects of ratoon stunting disease. Mr. Greenaway described the curative hot-water treatment campaign that had been carried out at various mills last year, as a result of which the Mackay district has approximately 180 acres of clean seed for further propagation this year. It was expected that this would in due course provide for every growers' full planting requirements for the 1956 season. Mr. Hughes gave the results of certain experiments which showed that a drop in temperature of 1° C. from the normal treatment temperature of 50° C. was responsible for 10 per cent. of the setts still retaining the ratoon stunting virus when treated for two hours, while 80 per cent. remained infected when the time of treatment was reduced to 1½ hours. This stressed the importance of maintaining a minimum temperature of 50° C. for the full treatment period of two hours, and if any canes would tolerate a slightly higher temperature it would be advisable to operate accordingly. Mr. Mungomery made reference to some of the results that were apparent in the clean seed campaigns that had been undertaken by various Cane Pest and Disease Control Boards. He showed that contamination could occur as a result of volunteering stools and through planting in situations where other diseases were prevalent. It was significant that the Boards which assumed the strictest supervision had made the greatest contribution to date in the supply of healthy cane, and he urged all Boards to adopt such a policy.

On the subject of pineapple disease, Messrs. E. Blundell and C. K. Simpson described and later demonstrated a new type of cutter planter which incorporates a dipping bath for organic mercurial solutions as distinct from the usual spray units. Messrs. C. G. Hughes and G. Wilson each presented details of experiments in which P.M.A. (phenyl mercuric acetate) had been compared with "Aretan" and similar organic mercurials, and they showed this compound to be equally efficacious as a protectant against pineapple disease.

It was decided to hold next year's conference in Brisbane and to request the Sugar Experiment Stations Board to hold a refresher course to enable some of the recently-appointed supervisors to become more fully acquainted with various cane diseases not now present in many parts of Queensland.

Before the conclusion, Mr. J. W. Inverarity referred to the interest which the Sugar Experiment Stations Board had in the work of the various Cane Pest and Disease Control Boards in conducting their huge clean seed projects which were being closely watched by overseas countries. He moved a vote of thanks to the Chairman who had so ably presided over the day's deliberations, and expressed thanks to the Mackay and Plane Creek Cane Pest and Disease Control Boards for entertaining delegates.

Appreciation was also expressed to Mr. S. Greenaway for his services as accommodation officer and to officers of the Bureau of Sugar Experiment Stations.

An Analysis of Trash Conservation*

By NORMAN J. KING

Reference has been made on previous occasions to the permanent trash trial on the Bundaberg Sugar Experiment Station. Although this experiment in trash conservation has been carried on without a break since 1933 no results in terms of extra tonnage per acre have been obtained. Over the period of the trial, including 1953 harvest, the plots on which trash was conserved from every crop totalled 414.1 tons of cane per acre, while the no trash plots, where all plant residues were burnt, aggregated 409.6 tons per acre.

It has been a matter of considerable discussion among farmers and agriculturists alike why no results were obtained from the trash treatment. Admittedly all plots received adequate fertilizer, and green manure crops were grown on the full area in each fallow period, so it was not expected that any benefits would accrue from the plant foods present in the trash. But in a dry zone such as Bundaberg, where average annual rainfall does not exceed 43 inches, and where no irrigation was practised, it was thought that the surface trash blanket in the ratoon crops would have helped to conserve more soil moisture and that this would have been reflected in increased crop. The figures given above show that this expectation was not realized.

It had also been argued that the considerable body of trash and tops which, after partially rotting on the soil surface, was ploughed in at the end of the rotation, would increase the organic matter and humus content of the soil and thus build up its moisture holding capacity. If this had occurred the extra moisture available should have resulted in better crop growth on the trash plots. The results show that this theory was also unsound.

What are the reasons for the lack of response to this treatment ? Firstly, we must consider the quantity of actual organic matter added to the soil and its relation to the soil to a depth of twelve inches. It has been found by actual measurement that to produce 56 tons of millable cane about 44 tons of green leaf and tops are grown at the same time. Consequently the 414 tons (approx.) of cane produced per acre would mean that 325 tons of green material, equal to about 59 tons of dry organic matter, had been turned into each acre of soil. Since an acre of soil, one foot deep, weighs approximately 1,350 tons, the 59 tons of dry matter equals 4.4 per cent. of its weight. So that for the 20 years of the experiment the average annual addition of organic matter did not exceed 0.22 per cent. of the soil weight.

We are inclined to over-estimate the value of organic matter in increasing the moisture holding capacity of soil. Text books state that peat may possess a water holding capacity up to 20 or more times that of a mineral soil—but what is generally overlooked is that the normal types of plant residues, when incorporated in the soil, have a moisture holding capacity about three times higher than that of a clay soil. If we accept a figure of this magnitude we arrive at the following conclusions:

An acre foot of soil with a field capacity of 31 per cent. moisture contains

$$\frac{1350 \times 31}{100} = 418.5 \text{ tons of water.}$$

The addition of 0.22 per cent. of organic matter with field capacity of 93 per cent. increases the moisture holding capacity by

$$\frac{.22 \times 1350 \times 93}{100 \times 100} = 2.76 \text{ tons of water.}$$

*Reprinted from the Proceedings of the Q.S.S.C.T., 1954.

In terms of available moisture on this soil type the 418.5 tons becomes

$$\frac{418.5 \times 20}{31} = 270 \text{ tons}$$

and the 2.76 becomes

$$\frac{2.76 \times 20}{31} = 1.79 \text{ tons}$$

on the assumption (perhaps invalid) that the available moisture in organic matter is in the same proportion as in the soil.

This calculation assumes that the 0.22 tons of dry organic matter remained fully active throughout each yearly period—insofar as moisture absorption capacity was concerned—and that none of it was lost by oxidation to carbon dioxide. Such an assumption, in a subtropical zone where high soil temperatures obtain in summer, is quite untenable and it must be accepted that the amount of organic matter active throughout the year—and the amount of retained moisture—were much less than calculated above.

But even taking the maximum figures quoted it is seen that the available soil moisture is increased by the trash treatment only from 270 tons to 271.79 tons —a rise of 0.66 per cent. It would be a very precise field experiment which could detect such a difference, either in terms of soil moisture or in resultant yield.

These figures indicate that, from the aspect of increasing moisture holding capacity in a soil such as the one under examination, there is little to be gained by trash incorporation. In practice the amount of extra moisture held is much less than calculated owing to the high rate of decomposition at temperatures in excess of 70° F.

The question arises as to whether the conservation of trash on the soil surface —as distinct from working into the soil mass—results in a greater proportion of rainfall being made available to the plant. The long-term Bundaberg trial does not indicate that such is the case. There, as explained earlier, the crop residues are conserved on the soil surface in alternate interspaces after each cutting. Any extra moisture which may be thus stored in the root zone of the crop is not reflected in additional cane. It must be accepted that, under the conditions of this experiment (even though it is located in a relatively low rainfall district) a trash blanket does not reduce evaporation losses sufficiently to affect crop yields. This soil type possesses excellent structure and its organic matter content, even after long cultivation, is normally in excess of 3 per cent. Some time after rain there is visibly more moisture in the surface soil under the trash than in the bare areas, but it is possible that the small percentage of soil moisture necessary to produce this visible difference is not enough to affect significantly the growth of the crop. It is also worthy of consideration that the relatively high organic matter content of this soil represents a state of equilibrium in the particular climatic environment, and that trash decomposition, where in contact with the soil, is too rapid to produce any lasting effect.

In Puerto Rico, Samuels, Landrau and Lugo Lopez [3] have shown a significant yield increase from trash aligned in alternate interspaces as compared with burning of all crop residues, but the increase was not achieved until the fifth and sixth ratoon crops. The organic matter content of the soil after the sixth ratoons was 1.425 per cent. in the trash-burnt areas and 1.700 in the trash-aligned sections; it is interesting to compare this with the 3 per cent. normally present in the Bundaberg trial.

In Jamaica, Muschett [2] compared surface mulching (in this case with grass at the rate of 120 loads per acre) with mineral fertilizing. Variable potash dressings were superimposed at the rate of nil, one and two hundredweights of muriate per acre. This trial was harvested to the second ratoon stage, the results indicating as an average of the three crops that

Mulch yielded 5.1 tons of cane per acre per year above the non-mulched plots.

Mulch plus one hundredweight of potash was slightly superior to one hundredweight of potash alone.

Two hundredweight of potash was slightly superior to the same amount of potash combined with mulch.

One hundredweight of potash alone produced 6.4 tons of cane per acre per year above the mulch alone.

In another Puerto Rican experiment [1] where a continuous trash blanket was compared with clean burning over a period of a plant and three ratoon crops no significant differences were obtained. All plots had been uniformly fertilized with a 14–6–8 mixture at the rate of 1,200 lb. per acre so that plant foods would not be a limiting factor. Rainfall for the four growing periods varied from 61 to 82 inches.

In South Africa, where complete trash blanketing is now almost uniform practice, it is claimed that no appreciable benefit accrues from the practice on first ratoons, but that there is a progressive build up in production in succeeding ratoon crops. It is also stated that plant crops, following the ploughing in of the trash blanket from the previous rotation, are not increased. From the evidence available it would appear that the greatest benefits are obtained when a partially rotted trash layer (in the second and third ratoon crops) is providing nutrients to the crop while at the same time cutting down evaporation losses from the soil surface.

Summary and Conclusions.

Trash and other mulching experiments in various sugar cane growing countries of the world have given variable results. An examination of the methods used and results obtained points to the following:—

Trash from crops of the magnitude normally grown in South Queensland is not sufficient, when incorporated in the soil, to raise moisture holding capacity appreciably.

Trash conserved on the surface, whether in alternate interspaces or as a blanket, does not result in significantly increased crop production. Benefits obtained from heavy grass mulching were obtained to an equal or greater extent by adequate potash fertilizing.

Results obtained from trash blanketing in late ratoons suggest that the increased crop is due, not to moisture conservation, but largely to plant food supply and availability.

No cognisance has been taken in this paper of other properties which organic mulches may possess. The reduction in weeding costs and prevention of erosion are two of these.

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The Conquest of Fiji Disease

In the late thirties and early forties five cane-growing areas in the State—each separate geographical units—were known to be infected with Fiji disease. These were Bundaberg, Isis, Maryborough-Bauple, Moreton, and Rocky Point. This disease did not occur in any districts north of Bundaberg.

The various Cane Pest and Disease Control Boards, established under Sugar Experiment Stations Acts, became active in disease control measures—principally by inspection and digging out infected stools. Simultaneously, the Bureau used its legislative powers to have badly diseased fields ploughed out or harvested early in the season, and in addition replaced susceptible varieties with new canes possessing disease-resistant or tolerant characteristics.

It is possible now to survey the trend of Fiji disease eradication achieved by these methods.

TABLE SHOWING DISEASED STOOLS DUG OUT EACH YEAR.

Year	Bundaberg	Isis	Maryborough	Moreton	Rocky Point
1938–39	2,314	139	—	4,155	—
1939–40	3,084	162	5,324	5,343	—
1940–41	3,606	171	4,453	6,298	—
1941–42	4,745	63	841	7,759	—
1942–43	5,859	183	393	8,450	—
1943–44	6,000	8	105	8,033	—
1944–45	7,475	4	72	11,000 app.	—
1945–46	3,988	49	84	11,000 app.	—
1946–47	2,288	0	29	10,721	—
1947–48	2,466	0	6	8,091	109
1948–49	1,015	0	1	3,342	91
1949–50	394	7	0	1,186	92
1950–51	141	0	0	189	93
1951–52	84	0	0	186	103
1952–53	14	0	0	35	13
1953–54 (to date)	0	0	0	12	40

The picture to-day is a reassuring one. Complete eradication has been accomplished in the Isis and Maryborough-Bauple districts and it is confidently expected that in Bundaberg and Moreton the final mopping-up will take place during the next year. Already one full growing season has passed in Bundaberg without a diseased stool being located, and the very small number found in the Moreton area demonstrates the measure of control attained. It is only seven years since these two districts aggregated 13,000 diseased stools in a year; last year the figure was twelve !

The people associated with disease control in Queensland can take pride in their achievements over the past quarter century. Firstly gumming disease, then downy mildew—the industry's two most serious diseases—have been totally eliminated. Within a year or so we will be able to claim equal success with a third one-time major disease—Fiji. What this means to the industry in cold cash it is impossible to compute. It is a sobering thought, however, that if downy mildew had not been brought under control, Trojan could not have been grown north of the Isis district.—N.J.K.

Chemical Weedicides—Mackay District*

By C. L. TOOHEY AND A. A. MATTHEWS

Introduction.

Outstanding success has been achieved with chemical weed control on the friable forest soils of the northern districts and on the volcanic loams of the southern areas of Queensland and although similar results have not been attained in the Mackay area some progress has been made. Most of the soils in this district possess heavy surface layers which crack badly under dry conditions, and impermeable clay subsoils. These do not lend themselves readily to the pre-emergence control of weeds and grasses, but the sandier loams, which occur in isolated parts of the district, are more amenable in this respect. In the eight years which have passed since the first weedicide trial was inaugurated on the Central Sugar Experiment Station, 17 different preparations have been assessed for their value in weed and grass control. In this investigation pre-emergence weedicides, contact weedicides and the root poisoning of special grasses have been studied.

Pre-Emergence Weedicides.

At the time of writing the high degree of success attained with pre-emergence spraying in other areas generally has not been achieved in Mackay. The results of the majority of a large number of trials have indicated the difficulty of controlling grass germination, which is the major cultivation problem of the area. An outstanding trial was laid down on a silt clay loam at the Experiment Station on 3rd October, 1950, during an extremely wet period. The treated area was sprayed with 2:4-*D* at the rate of four lb. per acre. Following six inches of rain which fell over ten

Fig. 12—Showing the trial block on 11th December. The left hand interspace received the chemical treatment, while that on the right was cultivated until rain prevented further work.

*Reprinted from the Proceedings of the Q.S.S.C.T., 1954.

days, some young barnyard and summer grasses appeared. The trial was then re-sprayed with a composite contact/pre-emergence mixture consisting of creosote with pentachlorphenol and 2:4-*D* at the rate of four gallons per acre. This killed the young grasses, only larger plants of barnyard grass remaining. An additional treatment with the contact/pre-emergence mixture was carried out on 22nd December, 1950, following five inches of rain recorded over 23 days. The trial was completely flooded for five consecutive days in January, 1951, but suffered no ill effects and the trial site remained clean until the end of June, 1951. This was the only instance when success against grasses was achieved by a contact spray. An important feature of this trial was the illustration that whereas cultivation under extremely wet conditions is impracticable, similar conditions would not hinder the use of a light tractor on the unbroken soil. One, two, or even three sprayings may then be performed.

The trial area as it appeared on 16th December, 1950, is shown in Fig. 12.

Contact Weedicides.

Contact sprays in this area have proved relatively ineffective against grasses although a certain amount of success has been achieved against broad-leafed weeds. The most important finding in chemical weed control experiments in the central area in that nut grass can be controlled for a period of up to eight weeks by the application of one lb. of 2:4-*D* per acre. This means that the previous practice of placing five or six inches of cover on setts in nut grass country for subsequent spinning off may now be eliminated. Instead, with a cover of two inches, two sprayings of 2:4-*D* at the above rate will control the nut grass for a period of 12 to 14 weeks, enabling the cane to become well established.

Noogoora burr, Star of Bethlehem and bellvine are also killed by a single treatment of 2:4-*D* at one lb. per acre. Two pounds per acre is sufficient to kill pink burr, star burr, flannel weed, winter weed and young lantana. A weed pest causing considerable damage on new land, viz., cane killing weed or *Striga*, is very easily eliminated by 2:4-*D* at one lb. per acre. Success against this parasite was also achieved with the triethanolamine salt of 2:4-*D* and the ethyl ester of 2:4-*D*.

Where Gambia pea has become a nuisance plant through inadequate cultivation practices it has been controlled by spraying with creosote mixtures containing various amounts of pentachlorphenol and 2:4-*D*, using two to three gallons per acre, and with emulsifiable pentachlorphenol at two gallons per acre. The creosote mixtures have also been used successfully against noogoora burr, star burr, flannel weed, *Striga* and bellvine at these concentrations. Neither these, nor emulsifiable pentachlorphenol, have so far proved completely satisfactory against grasses. A weedicide with a diesel oil base and containing pentachlorphenol and 2:4-*D* also proved ineffective against grasses, although it did control the same broad-leafed weeds.

Rapidly growing young sensitive weed was killed by the mixed esters of 2:4-*D* and 2:4:5-T at the rate of half a gallon per acre. A spectacular kill was also achieved with this weedicide on two-penny royals six feet in height, and well branched with profuse foliage. Guava bushes and young lantana are also susceptible to this weedicide.

In addition to the above sprays a mixture of sodium pentachlorphenate at three lb. per acre and a diesel oil formulation at one gallon per acre was also tried against several weeds and grasses. Little success was achieved except against bellvine and sida retusa, and even then a double application was needed to kill the latter weed.

Root Poisoning of Special Grasses.

In the central district the control of guinea and couch grasses with contact sprays has presented a major problem. Several weedicides have been used and to date the most promising is sodium trichloroacetate (TCA). TCA was originally tried against guinea grass at

the Central Experiment Station at the end of March, 1951. A plot of well established guinea grass was scythed and allowed to grow to a height of 18 inches. Three different trials with treatments of TCA at 25, 50 and 100 lb. per acre were established. A comparatively dry spell followed, and although burning of the leaves and cessation of growth occurred, there was no indication that the death of the plants was likely. A fall of an inch of rain at the end of April, and another of $1\frac{1}{2}$ inches in the middle of May effected a startling transformation. The most successful treatment was that of 100 lb. of TCA per acre which killed the guinea grass completely. Some new shoots appeared in the 50 lb. per acre treatment, but these were malformed. The guinea grass treated at 25 lb. per acre was affected but no plants were killed.

In an identical trial situated on a district farm, similar effects were observed. In this case evidence of the longevity of the treatment was also demonstrated. Following a successful kill at 100 lb. per acre a grass fire burnt out the trial section. Good rains fell subsequently, and although conditions were favourable for re-growth, the plot treated at 100 lb. per acre remained bare; re-growth occurred in the plots treated at 25 and 50 lb. per acre.

Subsequent trials set out have been aimed at the full utilization of TCA as a root poison. By spraying the weedicide on the foliage only, a certain amount of wastage occurs, so that areas to be treated are either scythed or mown and the weedicide sprayed directly in the stubble. Sodium pentachlorphenate, at the rate of 20 lb. per acre sprayed on the foliage dries off the top growth sufficiently to enable the grass to be fired after about five days. Young re-growth is then allowed to take place and TCA is applied in the normal manner. Investigations prove, too, that it may be possible to reduce the amount of TCA used to 50 lb. per acre, this being made up of two sprayings at 25 lb. per acre. The second spraying is performed on re-growth following the original spraying. Where convenient, if dry conditions persist, a light watering by boom spray may be made to carry the poison down to the plant roots.

TCA, and TCA in conjunction with sodium pentachlorphenate and 2:4-*D* have been tested against couch grass. Although results so far have been promising, no definite control can yet be claimed, and further trials on this grass are at present being carried out. Weedicides comprising mixtures of TCA, sodium pentachlorphenate and a diesel oil formulation have been used successfully by three mills in the Mackay district for controlling weed and grass growth on tramlines. It is claimed that this treatment has proved both superior to and cheaper than steaming or manual cleaning. Generally 10 lb. of TCA, 10 lb. sodium pentachlorphenate, and 3 gal. of a diesel oil formulation in 100 gal. of water were used per mile of line. The mixture was applied at a pressure of 80 p.s.i. The few well established plants of guinea grass remaining did not warrant an additional treatment, and were removed manually.

Conclusion.

Soil conditions of the central area for the most part prevent the general use of weedicides. However, specialization is, without a doubt, practicable.

On the sandier soils 2:4-*D* as a pre-emergence control, coupled with its use as a contact spray against nut grass, *Striga*, bellvine, Star of Bethlehem and the broad-leafed weeds make this weedicide an important accessory to the cultivation methods of this area.

TCA and sodium pentachlorphenate have a definite future in the control of guinea grass and on the basis of present experiments offer hope for the eventual control of couch grass. The main problem of the district—the control of grasses in general—has not yet been solved, and further work on weedicides to subdue these menaces to crop growth is needed.

Power for Sugar Cane Irrigation*

By J. H. NICKLIN

* All numbers in brackets refer to items in Table I.

Introduction.

Electric power from a Regional Board is now available in most cane-growing areas and when irrigation plants are being planned it would be advisable to consider the electric motor as an alternative source of power to the well known diesel engine. In this paper a number of cases involving drives of various horse-powers will be considered and for each case an estimate of the total annual power cost, for both diesel and electric drives, will be made.

Two farms having irrigated areas of 40 and 80 acres, respectively, will be considered and in each case the average quantity of water applied per year will be taken at 40 inches.

Pump Capacity.

It will be assumed that the water is applied in 10 waterings each of four inches. The quantity of water required for each watering of the 40 acre block

$$= 40 \times 43,560 \times \frac{4}{12} \times 6.25$$

$$= 3,630,000 \text{ gal.}$$

If the pump operates nine hours per day and each watering must be completed in nine days, the minimum pump capacity should be 44,800 gal. per hr. (approx.).

A suitable standard size would be 48,000 g.p.h. (800 g.p.m.) and such a pump would complete each watering in 7.6 days. For the 80-acre area 90,000 g.p.h. (1500 g.p.m.) would be a suitable capacity and would complete a watering in a little under nine days.

Horsepower Required.

Assuming an efficiency of 70 per cent., the horsepower required to drive a pump is given by the formula:—

$$\text{Horsepower} = \frac{\text{g.p.m.} \times 10 \times \text{total head}}{33,000 \times .7}$$

The total head is the height in feet that the water must be li ted *plus* the head in feet necessary to overcome friction caused by the flow through spears, pipes, valves, etc. In order to cover a fairly wide range of horsepowers total heads of 40, 80 and 120 feet will be considered for both the 40 and 80 acre blocks. In Table I details are given of the various costs for each of these cases.

The horsepowers obtained from the formula are those which would be required at the pump shaft. In the case of diesel drive an increase of 4 per cent. was allowed to cover belt transmission loss (4, 11).* Actual motor and diesel sizes which are considered advisable are given (5, 12).

Costs.

Running Costs.—The electricity used, or fuel and lubricating oil consumed in the case of a diesel plant, will depend on the number of running hours per year. The quantity of water required for the 40-acre block is 36,300,000 gallons; dividing this by the pump capacity—48,000 g.p.h.—gives a plant running time of 756 hours. In a similar way the plant running time for the 80-acre block is found to be 807 hours. Knowing the running hours, the units of electricity used per year may be found from the following formula:—

Electrical units

$$= \frac{\text{Horsepower} \times \text{hours} \times .746 \times 100}{\text{motor efficiency}}$$

The horsepower to be used in the above formula is that at the pump shaft (4). For all cases it is sufficiently accurate to assume a motor efficiency of 90 per cent.

Taking the 40-acre block at 40 feet head as an example the units used per

$$\text{year} = \frac{13.9 \times 756 \times .746 \times 100}{90}$$

$$= 8710 \text{ units.}$$

*Reprinted from the Proceedings of the Q.S.S.C.T., 1954.

The units used for the other five cases are worked out in a similar manner (6).

For the diesel driven pumps the fuel rates, in pints per horsepower-hour, for the different engine sizes were taken to be the maker's guarantee figures at three-quarter load *plus* 10 per cent. From these rates and the number of horsepower-hours required for each case the yearly fuel consumptions and costs may be determined (13, 14, 15, 16). Allowance must also be made for the lubricating oil consumed by the diesels; this consumption was based on the maker's figures per engine-hour *plus* 15 per cent. and the cost of oil was taken at 11/- per gallon (17). The cost of the distillate fuel required for these high speed diesels was taken at 2/3 per gallon.

Fixed Charges.—An examination of Table I will show that, if running costs only be considered, a diesel plant is a much cheaper proposition than an electric unit even with power costing only 3d. per unit. The installed cost of a diesel engine, however, is much higher than that of an electric motor and this fact must be taken into account if a true comparison of the two alternatives is to be made. The installed costs shown in Table I (9, 18) have been estimated for plants in the Burdekin District. Interest and depreciation have been taken at 10 per cent. Maintenance has been taken at 2½ per cent. on the electric plant (10) and 3 per cent. on the diesel equipment (19).

Attendance Costs.—In addition to the diesel costs already dealt with, it is considered that a small amount should be added to cover the handling of fuel oil and the little extra attention which should be given before and after starting an engine. This amount could be called "extra attendance cost" and has been evaluated on a basis of 10 minutes per pumping day *plus* 15 minutes for each 40 gallons of fuel handled with labour at 9/- per hour (20).

TABLE I

1	Area to be watered—acres	40			80		
2	Pump capacity—g.p.h. ..	48,000			90,000		
3	Total head—ft.	40	80	120	40	80	120
4	H.p. required at pump shaft	13.9	27.7	41.6	26.0	52.0	78.0
	Electric motor—						
5	Proposed motor size (h.p.) ..	15	35	50	30	60	90
6	Units used per year—kWh	8,710	17,420	26,130	17,420	34,840	52,260
	Costs—£—						
7	Energy at 3d. per unit ..	109	218	327	218	436	653
8	Energy at 4d. per unit ..	145	290	435	290	581	871
9	Installed cost	120	210	325	205	440	700
10	Fixed charges at 12½% ..	15	26	41	26	55	88
	Diesel—						
11	H.p. required at diesel shaft	14.5	28.9	43.4	27.1	54.2	81.3
12	Proposed engine size—h.p.	18	36	48	36	60	90
13	Energy used per year—h.p.hr.	10,960	21,920	32,880	21,920	43,840	65,760
14	Fuel rate—pints per h.p.hr.	.44	.40	.40	.40	.41	.41
15	Fuel used per year—gal. ..	603	1,096	1,644	1,036	2,247	3,370
	Costs—£—						
16	Fuel at 2/3 per gal. ..	68	123	185	123	253	379
17	Lub. oil at 11/- per gal. ..	4	7	9	7	14	22
18	Installed cost	640	1,160	1,440	1,160	1,510	1,860
19	Fixed charges at 13% ..	83	151	187	151	196	242
20	Extra attendance	8	9	11	10	13	16
	Total Annual Costs—£—						
21	Motor with energy at 3d. ..	124	244	368	244	491	741
22	Motor with energy at 4d. ..	160	316	476	316	636	959
23	Diesel	164	290	390	291	473	653

Total Annual Costs.—These, of course, are the sum of running costs and fixed charges and, in the case of the diesel, extra attendance costs. The total annual costs enable the more economical type of drive for each of the six cases considered to be selected at a glance (21, 22, 23). It will be noted that if electricity can be purchased for 3d. per unit the electric motor is the better proposition up to the 50 h.p. size. With electricity at 4d. the two alternatives are about equal for the 15 h.p. plant, but above that size the diesel is the cheaper.

General Solution.

One way of representing graphically the various cases detailed in Table I is to plot "total annual costs" against "acres × total head." For the electric drives a straight line relationship will be found to exist and the equation of this line would be:—

Total annual costs
$$= k \times \text{acres} \times \text{total head.}$$

The constant k will vary with the price per unit and reasonably accurate results will be obtained if it be given the value

$$\frac{\text{price per unit in pence.}}{40}$$

By making this substitution the following general equation is obtained—

Total annual power costs (£) for a 40 in. watering

$$= \frac{\text{acres} \times \text{feet head} \times \text{pence per unit}}{40}$$

Plotting the diesel costs in the same way gives a curved line for which it would not be possible to derive a simple equation. It might be remembered, however, that up to an "acres × head" figure of 2,000 the annual diesel costs are about the same as annual motor costs when the price of electric energy is 4d. per unit.

Deep Cultivation

A short article in the Louisiana Sugar Bulletin, January 15, 1954, describes results obtained on various sugar plantations as the result of deep tillage. The opinions expressed by plantation agriculturists were unanimously in favour of the practice and it should be noted that they refer to cultivation to a depth of 16 or 18 inches.

In Queensland there is a paucity of data on this phase of cane growing. During the thirties some experimentation was carried out in the Bundaberg area where the Fowler steam grubbers were still in operation on red volcanic soils. At the same time the Sugar Experiment Station, on the same soil type, tested the effect of deep subsoiling —to a depth of 18 inches—in every plough furrow as the land was being ploughed. In neither case was an increase in cane yield obtained.

However, there is good reason to believe that cultivation practices which are not beneficial on red volcanic soils, with their excellent physical condition, may give entirely different results on other, more intractable types.

The Louisiana experience is interesting in the light of our recent investigations into the use of bagasse on soils, combined with deep ripping to a depth of 22 inches. In those experiments we visualise the broken up, clayey subsoil as an extra moisture reservoir in dry periods and we feel that roots will be able to feed on plant foods in the clay layer which were previously unavailable to them. Deep tillage alone should have the same effect except that, in the absence of bagasse, the clay may not remain broken up for so long a period. Either method is well worthy of trial, and any cane grower with a high powered tractor, capable of breaking up the subsoil to a depth of some 18 inches, should measure the value of the method on his own farm. Subsoil cultivation should show maximum results on soils where the surface is shallow and the subsoil heavy and impervious to moisture.—N.J.K.

Chlorotic Streak Disease at Mackay

By C. G. HUGHES

Chlorotic streak disease is one of the diseases familiar to pathologists in many cane-producing countries. It was recognized only 25 or so years ago but was soon found to be present in Java, Hawaii, Puerto Rico, and Queensland.

Fig. 13—Yields from small but comparable plots of healthy (left) and diseased (right) P.O.J.2878.

Fig. 14—Chlorotic streak on leaves of Trojan.

Since then it has been found in Fiji, Louisiana, British Guiana, Colombia, Taiwan, Mauritius and South Africa, and in many instances is recognized as a cause of serious losses in susceptible varieties. Observations have indicated the damage the disease may cause and confirmatory, properly planned trials have shown that significant losses occur in several countries. A trial in Hawaii for example showed a loss of 15 tons of cane per acre in the variety H.44—3098 due to the disease, and trials with P.O.J.2878 in Queensland and Puerto Rico have shown losses of 10 and 15 tons of cane per acre respectively.

The chief symptoms, which give the disease its name, consist of longitudinal, whitish or yellowish streaks of variable length and width in the green tissue of the leaf blades. From one to many streaks may occur on any one leaf and the typical streaks are seen only on the younger leaves; on older leaves the streaks show areas of dead or dying tissue and are often lost in the general discoloration associated with the ageing of the leaf. The streaks are not obvious at all times of the year and in some varieties even badly diseased fields may not show a single streak for quite long periods. However, just because the obvious streaks have disappeared, it does not mean that the crop has recovered, and a high proportion of plants taken from such a field will produce diseased stools.

General symptoms of chlorotic streak consists of poor germination, poor, weak ratooning with occasional death of stools, and a general reduction in crop yield, the extent of which is indicated in the trial results quoted above.

The disease is known to occur in Queensland in all mill areas north of Townsville and at Maryborough, Moreton and Rocky Point in the south.

In the intermediate areas it has not been found at Ayr or Bundaberg or in the Isis, but it has been common for some years at Proserpine, and only last December was found in the Sarina area. Until the discovery at Walkerston on 22nd April this year, it had never been seen in the Mackay district. There it was found on two adjoining farms and in a range of both commercial and experimental canes. Plantings of Trojan, Q.28 and Q.50, among the commercial varieties, showed the disease while some nine promising new canes in an experimental plot were also diseased.

The question as to how the disease got to the Mackay district is one that cannot be answered precisely, but it may not be without significance that some eight years ago an illicit planting of cane was made on one of the infected farms. This cane had been brought without permit from the Ingham area, where chlorotic streak has been known for many years, and it is possible that the plants used were infected. A successful prosecution followed the illegal transfer and the plants were ploughed out and destroyed, but even so it is possible that adjoining cane became infected and so allowed the disease to be carried on to this day.

Chlorotic streak is usually a serious disease only in localities where the soil remains wet for comparatively long periods, and the actual area involved in a particular district may vary from year to year, depending on the nature of the wet season; in years with a short season only badly drained soils show it; in years with a longer wet season the disease may spread on to fairly well drained soils.

The disease at Mackay has so far followed the same general pattern. It has been found only in wet, poorly drained fields and, as it happens, after a prolonged wet season. As this goes to press a survey is being conducted by the Bureau and the Mackay Cane Pest and Disease Control Board to determine the limit of spread of the disease and so provide a basis for the control measures to be applied. The immediate aim of these measures will be to confine the disease by preventing the transfer of diseased plants, but the ultimate goal is the complete control and possible eradication of it as an influence in reducing crop yields.

We do not know what organism is responsible for the disease—it may be one of the disease causing agencies called viruses, although some authorities think a fungus may be responsible—but we do know that it can be carried over from one crop to the next by the planting of setts from diseased plants. It is obvious then that setts must not be taken from diseased fields nor from adjacent fields. If a farmer is in doubt as to the health of the plants he is thinking of using he should immediately contact the Sugar Experiment Station or the Cane Pest and Disease Control Board. Avoidance of suspect or diseased fields as a source of plants is one measure of control and the most important available to the farmer. There is, however, a heat treatment which, like that for ratoon stunting, can be used for rendering setts free from chlorotic streak. It involves treatment in water at 52° C. (126° F.) for 20 minutes, which is a less severe treatment than the two hours at 50° C. (122° F.) required for the control of ratoon stunting disease.

The resistance of varieties does not offer much hope for the control of the disease in the Mackay district, since nearly all the canes on the approved list, with the exception of Co.290, appear to be susceptible to the disease. It is true that on its behaviour in northern mill areas Q.50 appeared to be resistant to the disease but limited observations at Mackay indicate that, judging by the number of streaks produced, it is fairly susceptible. Of the other varieties on the list, Badila, E.K.28, M.1900 S., Pindar, P.O.J.2725, P.O.J.2878, Q.28, Q.45 and Trojan are known to suffer losses when infected, but observations on Comus and S.J.2 have been too few for an opinion to be expressed. Varieties vary in the display

of symptoms and it is important to know whether a variety may be expected to show symptoms for a long period or for only a few weeks. The Mackay approved canes Trojan and Q.28, along with the advanced experimental canes C.P.29/116 and N.Co.310, show the streaks very well over a considerable period; Badila, M.1900 S., P.O.J.2725, P.O.J.2878 and Q.45 show them well but for only a limited period; while Q.50 and Pindar are variable from year to year.

Chlorotic streak disease may not always be easily recognized and its control does at times present a problem, but there is no reason to doubt that the combined efforts of the Bureau, the Cane Pest and Disease Control Board and, most important of all, the farmers, will prevent this disease causing serious losses in the Mackay district.

Green Crops in the Nambour District

Nambour farmers have for quite a number of years been growing a legume crop of Poona pea with prodigious success, but during the last two or three seasons diseases (stem rot and wilt) have made considerable inroads into the density and vigour of the crops. This sudden advance of the diseases could be due to suitable conditions brought about by the past two beneficial seasons, but whatever the cause, large portions of the crops this year are a distinct loss and a more disease resistant type of legume will have to be grown.

One type, which comes to mind and which has already been introduced into the Nambour district, is the velvet bean. This variety was not favourably accepted here when first planted but is now gaining popularity because it has shown tolerance to both wet and dry periods, whilst its resistance to disease is very high. Planting is carried out either by broadcasting or sowing in drills, approximately 4 feet 6 inches apart, usually the latter, spacing the seeds about 9 inches and at the rate of between 12 and 15 pounds per acre.

Germination is normally good and when planted in rows it is necessary to carry out two or three scarifyings before the vines cover the interspace. Although their growth period is approximately six months, the quantity of green matter produced at any time is comparable to that of Poona pea and eventually yields a greater mass.

When in a green and vigorous state a good crop of velvet beans appears to be a formidable mass to handle, but if the vines are allowed to dry out on the surface of the field the operation of turning them into the soil is easily accomplished either by ploughing or discing, preferably discing. In contrast to Poona pea, the velvet bean when turned under in the dry state does not produce a volunteer crop of any consequence and normally these volunteers do not constitute a problem in the subsequent cane crop.

From the preceding description of the growth habits of this type of legume it can be seen that it is ideally suited to the Nambour district, where there is only one planting period and nearly all the fields have an average fallow of nine months.—C.A.R.

Knapsack Spray Improvement

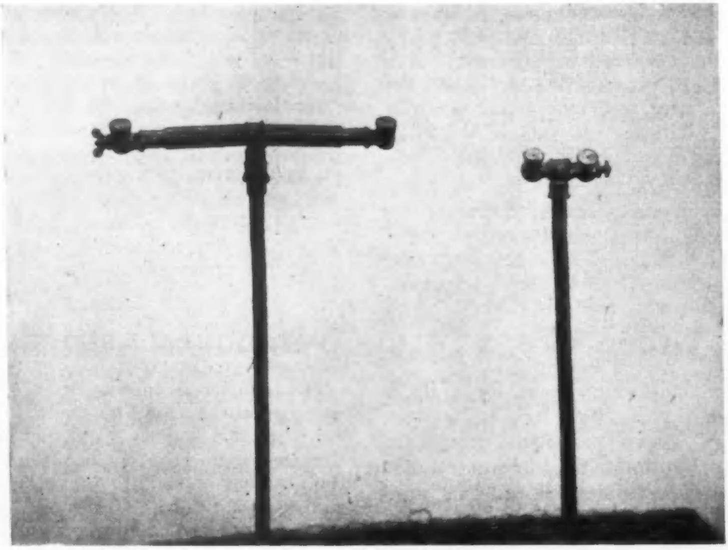

Fig. 15—Showing the original (right) and the altered (left) knapsack spray nozzles.

Where it is necessary to use a "Rega" knapsack spray for contact weedicide operations it has been found that the work may be expedited and made less fatiguing by extending the width of spraying centres on the double cyclone nozzle.

The material for these alterations costs a few shillings and any cane grower or handy man on the farm can perform the conversion in an hour.

The method adopted at the Mackay Sugar Experiment Station was as follows:—

To the raised shoulders on each side of the centre bearing of the nozzle was attached a piece of ¾ inch outside diameter copper tubing 2¾ inches in length. It was found that ¾ inch outside diameter was the size required to fit over this shoulder. Inside the free end of the tubing was sweated a piece of ⅝ inch O.D. copper tubing, total length two inches, allowing ¾ inch of this two inches to extend. This ⅝ inch tubing fits into the shoulder of the spray nozzle. Total length of extension is 3½ inches on each side of the centre bearing of the nozzle, giving an increase of seven inches to the normal double cyclone nozzle. Basil leather washers are used to seal points of contact between copper tubing and parts of the cyclone nozzle.

The short pin for connecting the double cyclone nozzle is replaced by 9¾ inches of $\frac{3}{16}$ inch brazing rod threaded at both ends, one end is screwed into the shoulder of the nozzle, while at the other end the normal nozzle nut is replaced by a $\frac{3}{16}$ inch brass wing nut.

The extensions altered the distances between the centre of holes on the faces of sprays from 1⅞ inches to 8⅞ inches and increased the ground coverage from 18 inches to a minimum of three feet with nozzles held 30 inches from the ground, which is normal closed hand length from the ground.

The photograph illustrates the normal and extended nozzles.—C.G.S.

Mackay Field Day

The Annual Farmers' Field Day was held at Mackay Sugar Experiment Station on April 30th. The occasion coincided with the Conference of Cane Pest and Disease Control Boards which was in session at Mackay, and afforded an opportunity for visitors from other districts to see the local Station.

Fig. 16 —Mr. J. W. Inverarity addressing growers at Mackay Field Day.

The function conformed to previous practice. From 10 a.m. onwards cane growers and other visitors were taken around the Station blocks in small parties, and the guides in charge (officers of the Bureau Staff) explained in detail the work proceeding on each area. The development of new varieties, from the stage of tiny, grass-like seedlings to the final selection trials was observed; the effects of various weedicides was examined; velvet bean crops were in evidence; the New Guinea canes were seen in trial against local varieties; and an excellent implement and tractor display was on show. Simultaneously the symptoms of ratoon stunting disease were explained by a Bureau pathologist, and diseased canes were sectioned to demonstrate the internal markings.

Almost 600 visitors entered the Station grounds during the Field Day. Many were from distant Mackay areas and a number of Proserpine representatives were noticed in the gathering. Fifty or sixty Cane Pest and Disease Control Board delegates attended.

A light luncheon was served between 12.30 and 2.00 p.m., after which Mr. J. W. Inverarity, a member of the Sugar Experiments Stations Board, welcomed the visitors and addressed them on the Bureau work in general. Short addresses were delivered by the Director (Mr. N. J. King) and the Officer-in-Charge, Entomology and Pathology Division (Mr. R. W. Mungomery). Mr. E. Evans, M.L.A. (representing the A.S.P.A.), Mr. W. Holding (representing the Q.C.G.C.) and Mr. F. D. Graham, M.L.A., member for Mackay, also spoke of problems facing the industry and of the efforts being made ot surmount them.

Mr. King's Address

During the course of your walk around the Station to-day you have unfortunately not had the opportunity to examine a trial using bagasse from the mill. No doubt many of you are curious to know why we are using this material and what we hope to achieve in soil improvement or crop increase.

To make the position quite clear it is necessary to consider the soil type on which we are located at this moment—a type which is characteristic of so much of the Mackay district. Here we have a relatively shallow surface soil underlain by heavy clay and in other parts of the district, particularly south from here, the surface soil is shallower and the clay somewhat heavier. Even in its virgin state Mackay forest soils do not possess a good physical condition and this is certainly not improved by generations of cane farming. Since

it came under cultivation the natural soil structure has deteriorated as the result of working with implements, waterlogging in wet seasons, mixing of subsoil clay with the surface layer, and compaction by tractors and trucks.

This is all on the debit side; what is there on the credit ? During the same period the roots and stubble after each rotation have rotted in the soil and supplied some material to improve soil structure. In some cases green manure crops have been grown and ploughed in, and on many properties lime has been applied periodically partly to correct soil acidity and partly as a soil ameliorant. But all of these practices are affecting only the surface soil.

The heavy clay subsoil remains as a barrier to the free penetration of water and is an obstacle to the bulk of the cane roots in their search for plant food and moisture.

Even heavy clays contain plant food supplies and the local subsoils are no exception. But these plant food supplies remain locked up and unavailable if the roots are unable to penetrate the clay in the same way as they do the surface soil. Farmers have recognised this difficulty and have attempted to overcome it in some cases by deep grubbing. The idea behind this practice was to make gashes through the clay, thus allowing roots to go down beyond the normal depth; at the same time the subsoil was not brought to the surface. But this method was only partially successful. In the first place the normal farm tractor power was insufficient for really deep grubbing, and secondly the first wet season caused the clay to run together again and seal up the gashes.

Fig. 17—Growers arriving at the Station on the morning of Field Day.

In the past year or two some Mackay growers on land which has been farmed for long periods have overcome the first objection by engaging deep rippers on contract to loosen up the subsoil to a depth of 22 or 24 inches. This appears to be a good scheme, but it remains to be seen for how long the subsoil will remain in a broken condition.

This brings us to the bagasse treatment which I referred to earlier in this

address. The idea is to use bagasse in conjunction with deep ripping. After final ratoons are harvested bagasse is spread on the hard soil surface and the land is then ripped. It will be seen that, as the ripper tynes break through the soil, part of the bagasse runs down the crevices into the subsoil clay; the remainder stays on the surface. We found it desirable to rip the land twice because of the wide spacing of the tynes. Subsequent land preparation mixes this remaining bagasse with the surface soil, and it is desirable to grow and plough in a green manure crop to ensure a good nitrogen supply in the soil.

You can visualize the effect of this procedure. The subsoil is broken up to a considerable depth and the bagasse which runs down prevents the clay from closing up altogether during a subsequent wet season. These openings in the subsoil allow water to penetrate more freely and thus use the subsoil as a water reservoir; the cane roots can follow the channels and thus locate plant food and moisture otherwise unavailable to them; and since the fibre of bagasse is resistant to decomposition the effect should be lasting.

I had the opportunity of seeing this method in operation last year in Jamaica, in the British West Indies, and plantation managers were enthusiastic regarding the results on heavy clay soils. In particular they stated that the crops stood up better to dry spells, presumably because of the subsoil water storage. This is important in the Mackay area, where seasonal crop fluctuations are closely related to dry periods when cane has depleted the available soil moisture.

It is very important that the bagasse application be followed by a green manure crop, or by a dressing of sulphate of ammonia at planting time. Either practice will prevent the possibility of nitrogen starvation in the young cane crop. During the process of decomposition of the bagasse in the soil the organisms responsible require a supply of nitrogen. If this is not made available the cane crop might suffer.

Fig. 18—The line-up of tractors and implements which were on display.

We come to the problem of bagasse supply. Naturally there is not sufficient for everyone's needs and the low density of the material will make transport costly. It will probably be economic only for growers who are situated close to the mills. In Jamaica and also in Barbados it was noted that the bagasse was taken to the field in baled form and this method reduced transport costs considerably, but it would necessitate an arrangement between miller and grower.

You may have some doubt as to whether this practice will result in increased production. At the moment we cannot state that it will, and we will not have precise information on the subject until the trial on this Station is harvested—both in the plant and ratoon crops. But I think we will all agree that this district's potential for cane growth is greater than that of some other areas where crops are consistently larger. Why is it that with a 60 inch rainfall and a more tropical climate, Mackay's yields per acre are always lower than Bundaberg's? The answer lies, not in climatic conditions or cane varieties, but in soil conditions. If you can improve your soil physically your cane crops will be able to take better advantage of the rainfall and temperature. Soil improvement is not an easy job but it is one which justifies appreciable expenditure, particularly with cane at its present price. If your soils can be opened up with bagasse and deep tillage you will probably notice improvements in more than one direction. Quicker drainage will allow earlier working after rain and this is a major advantage in a district such as this. There is a lot to be said for being able to cultivate and plant as soon as possible after the wet season.

Our efforts on these Experiment Stations are aimed at making cane growing a more profitable occupation for all people involved. A new cane variety can mean increased wealth to the district; control of an insect pest, whether it be grub, wireworm or locust, adds to the grower's income; eradication of a disease removes a menace which threatens the crop. In the same way a new cultural practice can improve the economics of cane growing if it gives increased crop, reduces cultivation costs or allows earlier planting.

Mr. Mungomery's Address

At times like the present when there is the likelihood of sugar production being in excess of Australia's guaranteed markets, it may seem inopportune to attempt to enlist your enthusiasm and support for the more efficient control of pests and diseases. In fact, in the case of some crops, a high incidence of pests and diseases is regarded as a sure means of eliminating surpluses and of maintaining a high market value for the produce ultimately harvested. This attitude has lately been translated into terms the sugar grower will readily understand when one hears such expressions as "Let's have more ratoon stunting disease" or "Stop using benzene hexachloride for a few years," implying, of course, that grubs and diseases should again be allowed to take full toll of Queensland's cane crops. This attitude might suit those who have never been seriously embarassed by pests or diseases, but it would spell ruin to many growers who are farming in areas ordinarily vulnerable to pest attack, while diseases would ultimately endanger the whole industry were their spread not restricted in some way or other. In whatever way one looks at the question, pests and diseases do not benefit the nation, nor do they benefit the individual grower who wants to harvest as large a crop as possible.

Losses from pests and diseases are often discussed in monetary terms, and while it is well to have this aspect prominently before us there are other ways of looking at the matter. These losses may be regarded as that portion of the harvest taken by pests and diseases and therefore as crops unharvested by the grower, or merely as unharvested acres. If these losses were eliminated it would mean greater production per acre and that the same tonnage could be produced on a smaller acreage. That

is to say, there would be less land preparation, less cane used for planting, less cultivation, etc., with a consequent lowering in the cost of production. Any surplus land could then be used for the production of other food crops or for the growing of green manure crops to restore soil fertility, and this would be one way of maintaining incomes in the face of rising costs.

In pest control operations we are prone to speak about attacking the pest at the weakest link in its life history, but what is really meant is that it should be attacked at some point where control is cheapest and easiest.

Furthermore to be an economic proposition the expected gain in production must be greater than the costs incurred in destroying the pest. Consequently a grower's investment in pest control must be regarded as a dividend producer.

Let us enquire into the question of grub control. We know that in BHC we have an effective insecticide for controlling these pests. The cost of control is about £4/10/- per acre for a three year period or about £1/10/- per acre per year. In examining results from a number of our BHC experiments against grubs in North Queensland and averaging yield differences in both lightly and heavily infested areas it was found that there was an average yearly gain of six tons per acre in favour of the BHC-treated plots. To put it in other words, for an investment of £1/10/- per acre in pest control there was an average return of about £20 per acre after allowance was made for harvesting costs. Even if the crop increase amounted to only one ton per acre this extra amount would still more than have covered application costs. Where growers are farming areas regularly subject to grub attack there is no risk attached to grub control operations. BHC is a sure grub destroyer if applied correctly and the extra crop gained has a definite market value. Hence there is profitable return for the money expended and the only sensible course open to growers in grub-infested areas is to practice some efficient form of control.

Losses in the central areas over the past few years provide a good reason for an extension of this policy.

Much has been said from time to time about grasshopper control. Swarms of the yellow-winged locust visit the central coastal areas on an average about every 10-15 years, and before embarking on any control programme full consideration must be given to the damage caused by these pests and the costs involved in their control. Control might be attempted in two different ways according to different viewpoints. The first would aim at the destruction of incipient swarms, and would involve a regular patrol of the outbreak centres on the other side of the Dividing range. This would be a costly undertaking and it would have to be attempted on a broad basis and not left to be financed by one section of primary producers alone. Since the cost would ultimately have to be borne by the taxpayers it would have to be demonstrated that the losses caused by these outbreaks outweigh the costs incurred in keeping the pest permanently suppressed. The second method is to protect the crops in the coastal areas as they become liable to attack. This has been the method adopted with a considerable measure of success to date and doubtless this could be further improved by a greater co-operative effort. Any compromise between these two methods would mean attacking vast swarms over extensive areas of cattle country where the value of the natural pasture is low, and in such a case the cost of control operations would be likely to exceed any damage which the pests might do.

Ratoon stunting disease, too, has been responsible for depriving the grower of a portion of his legitimate harvest as many Mackay and Proserpine growers only too well remember, but it is pleasing to see the efficiency with which the Cane Pest and Disease Control Boards in the central districts are tackling this problem by providing blocks of clean cane which will be

further propagated and ultimately distributed. Keeping these plots of healthy cane under Board supervision has eliminated much of the contamination through volunteers and other diseases that has unfortunately involved a certain amount of wasted effort in other areas where attempts have been made to hot-water-treat a small quantity of cane for each grower. It is not clear at this stage just how long the hot water treatment of planting material will have to be continued, but since some of the clean stocks may become re-contaminated, fresh stocks will have to be treated for a few years at least and these will serve as nuclei from which the healthy material will continue to be propagated. The possibility of re-contamination cannot be too strongly stressed. Unfortunately some overseas countries have referred to the curative hot-water treatment as an "immunisation" treatment.

This of course is quite wrong, and no immunity is conferred on the cane by virtue of its having contracted the disease and been cured of it earlier. Contaminated knives and the blades of cutter planters can transfer the ratoon stunting virus to healthy cane if they have previously been used for cutting diseased cane without subsequent sterilizing. Growers therefore are urged to sterilize their implements and cane knives before cutting their healthy cane either for planting or for milling and to co-operate fully with Cane Pest and Disease Control Boards in overcoming a disease which otherwise will take some of their legitimate harvest and raise their costs of production.

Nut Grass *(Cyperus rotundus)**

By C. G. STORY

This creeping perennial, a member of the sedge family (*Cyperaceae*), is widely distributed as an agricultural weed in the tropical and sub-tropical regions of the world. It is present in many areas cultivated to sugar cane in Queensland and generally occurs on the better class soils where its moisture robbing properties and nuisance value are well known. Its presence on cane fields has meant more cultivation than most growers desire, with consequent increase in production costs, especially with young plant cane.

Fortunate is the cane grower who does not possess nut grass on his property. This weed has been the subject of special study by a number of overseas investigators working on crops other than sugar cane and the following information on itsgrowth and characteristics will enable cane growers to appreciate the principles behind the control of this plant both by cultivation and/or chemical weed control. Sugar cane gives a measure of control through shading the rows by dense cover of the leafy tops when cultivation of cane has ceased, but it needs constant attention before that period of cane growth is attained. Nut grass does not favour any particular soil type provided there is an abundance of moisture.

The set of seed and seed viability is so low with nut grass that although it flowers prolifically this method of propagation and dispersal is not as important as that by the tuber (the much enlarged short fleshy underground stem commonly known as the nut). These tubers, which are torpedo shaped and seldom larger than half inch in diameter by one inch long are borne on dark scaly rhizomes one eighth of an inch or less in diameter. The rhizomes (elongated underground horizontal stems) are incapable of establishing new plants when isolated.

*Acknowledgment for much of the material used is made to Robbins, Craft & Raynor's "Weed Control."

Patches of nut grass increase in size through dispersal of the tubers by cultivation implements and by natural vegetative spread, which is rapid under favourable conditions. A single nut produced a system of 146 tubers and basal bulbs in $3\frac{1}{2}$ months in a greenhouse experiment. It was found that a new tuber may be formed in about 21 days after the planting of an isolated tuber.

When an isolated tuber germinates, it sends out a rhizome that grows to the surface and terminates in an aerial shoot. A tuberous enlargement, termed a "basal bulb," develops at the juncture of the rhizome and leaves. Basal bulbs, like tubers, contain stored food and produce rhizomes from buds at nodes. A rhizome originating from a basal bulb extends laterally for a few inches before enlarging into a tuber. The terminal bud on a tuber may then send out a new rhizome, which, in turn, terminates in a second tuber, and so on until a chain of a dozen or more interconnected tubers is formed; or the rhizome from the first or any succeeding tuber may grow upward and terminate in a basal bulb and aerial shoot. Lateral buds on some of the tubers in a chain may likewise either extend as a side chain of tubers or send a rhizome to the surface ending in a shoot.

Since all tubers do not send rhizomes to the surface to start new shoots, the number of shoots on a given area does not necessarily indicate the number of tubers beneath the area. Investigators found that apical dominance in a rhizome chain prevented all tubers in the chain from germinating simultaneously. Thus, if an unbranched chain of several tubers is dug up and replanted, the terminal tubers (one at each end) germinate first, whereas the intermediate ones are largely repressed; and in a chain with side branches, those at the end of the branches germinate at the same time as those at the ends of the main chain.

The depth distribution of tubers is a function of soil conditions. Tuber distribution varies according to aeration conditions at different depths. In loose, well-aerated soils, tubers occur at greater depths than in heavy, impermeable ones or where a high water table limits aeration at lower levels. The highest concentration of tubers is found in the surface foot in most soils, although in some it may be in the second foot. Only seldom are tubers found much below 24 inches. Feeding roots, which originate on the tubers, penetrate the soil to a depth of several feet. In one excavation where tubers were confined to the surface foot feed roots were found at a depth of 54 inches.

Control by Cultivation.

Cultivation as a method of controlling nut grass has two objectives: (1) severing the feeding roots from their connection with moist soil below and throwing as many of the tubers as possible to the surface, where they will be killed by drying out; and (2) exhausting the carbohydrate reserves in the tubers by repeated shoot cutting. During a dry season, and where the soil may be dried to below the wilting point to the full depth in which tubers are found, a single operation, properly carried out, will result in the death of all tubers from drying out. But in regions having frequent rains during the growing season, exhausting the root reserves by repeated defoliation is more important than the injury to tubers through drying out.

Nut grass tubers will survive almost indefinitely in dry soil if their feeding roots are in contact with moist soil below, but if the feeding roots are severed, the tubers dry out, and when their moisture content drops to around 15 per cent., in contrast with the normal moisture content of around 50 per cent., they die. The drying time required to kill them depends on depth of burial, moisture content of the soil, and temperature. Those exposed on the surface of dry soil may be killed in as little as four days in direct sunlight and low humidity; or it may take up to two weeks during periods with high humidity and cloudy days. Those buried two to four inches below the surface will

require eight to 16 days. Implements must be used at sufficient depth to disturb the lowest tubers. This will be about 12 inches in most soils.

Since the soil may never dry out enough in humid regions to permit effective use of the system just described for use in arid regions, cultivation must be continued at intervals until the tuber reserves are exhausted.

Investigators found that discing or ploughing whenever shoots were general in the area—approximately every three weeks—during two seasons resulted in control. The effect of such constant cultivation on the physical texture of most cane soils could be well imagined. The plough and disc break the rhizome connections completely and so minimize the effects of apical dominance.

The relation of apical dominance to tuber starvation is as follows: if the tops of the plants are merely clipped, the starvation process will be gradual, since the system may contain many dormant tubers that serve as storehouses of reserve food. These reserve foods may be translocated from the dormant tubers as the active tubers are exhausted; after the active tubers have died the dormant tubers may then germinate. If, however, the tubers are separated from each other, and all begin to germinate, then the starvation process should be materially hastened.

There is also the added advantage of discing or ploughing in that these implements, in turning the soil, bring more of the tubers to the surface for rapid drying out in air and sun than where the soil is merely stirred with a cultivator. The shading effect of summer legumes on fallow blocks will check nut grass.

Control with Chemicals.

Chemical weedicides have altered the whole aspect of nut grass control in cane fields. Nut grass can be controlled for a period up to eight weeks by the application of one pound per acre of the sodium salt of 2,4-D at 8/3 per pound. The previous practice of placing five or six inches of cover on setts in nut grass country for subsequent removal by spinning off or by raking may now be eliminated. Instead, with a cover of two inches, two sprayings of 2,4-D at the above rate will control the nut grass for a period of three months, enabling the cane to become well established. The lighter cover would allow a more rapid germination after planting. The applications may be blanket spraying over the whole block or spraying of the row only. In the latter case it is often found that spray drift will account for death of the nut grass over a larger area than that treated.

Nut grass is no longer a problem in the cultivation of sugar cane, thanks to the modern scientific development of chemical weed control which is much cheaper than the constant cultivation by implements necessary to achieve the same result. The latter could be detrimental to physical condition of the soil. In certain cases a combination of both spraying and cultivation at planned intervals may be more suitable to a particular farm programme or soil type.

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